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Spatial Dimensions of Trade Liberalization and Economic Convergence: Mexico 1985-2002*

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Abstract: This paper studies the spatial dimension of growth in Mexico over the last three decades. The literature regional economic growth has shown a decrease regional dispersion from 1970 to 1985 and as sharp increase afterwards coinciding with the trade liberalization of the Mexican economy. Using spatial econometric tools we analyze how the process of convergence/divergence has mapped spatially and whether it makes sense to talk about spatial regions in Mexico. Although the rich North/ poor South dichotomy has, overall, dominated this phenomenon, interesting patterns emerge. Namely that the distribution of growth after Mexico's post liberalization seems to be much less associated to distance to the US than initially expected.

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I. Introduction

The 17 years beginning with Mexico's dramatic unilateral trade liberalization in 1985 and including the North American Free Trade Agreement (NAFTA) have seen increasing divergence of per capita incomes among Mexican states. Measures of sigma convergence show a decrease in dispersion from 1970 to 1985, and then a sharp reversion to traditional levels of inequality thereafter. A growing number of studies using traditional beta convergence analysis,[1] find at minimum a slowdown of convergence, and most divergence (Juan-Ramon and Rivera Batiz 1996, Esquivel 1999, Messmacher 2000, Cermeño 2001, Esquivel and Messmacher 2002, Chiquiar, forthcoming). Of emerging concern is that this divergence is manifested in particular geographical patterns that will compound traditional inequalities: the northern states will take most advantage of free trade and rapidly converge to US income levels while those further south will continue their historical lag, polarizing the country. However, neither the links from trade liberalization to the spatial location of economic activity, nor to economic convergence are well understood, theoretically or in the particular case of Mexico. This paper employs established tools in the spatial economics literature to investigate both.

Background

Mexico in 1985 began a process of unilateral liberalization shifted from an inward looking policy of import substitution to a policy of trade liberalization that included a dramatic reduction of import licensing covering 90% domestic production to 23% by 1988, a reduction of average levels of tariffs from 24% to 11%, and joining the general agreement on tariffs and trade (GATT) in 1986. The pursuit of NAFTA, signed in 1994 would lead to a further reduction of tariffs to 1.3% by 2001, the progressive liberalization of sensitive sectors, as well as increased access to the US market and, it was hoped, a greater confidence that the reforms would be locked in and hence make foreign direct investment more attractive.[2]

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[1] See Barro and Sala-i-Martin, 1995

[2] See Lustig, Bosworth and Lawrence (1992) and Lederman, Maloney and Serven (2005).

Much of the work analyzing the impacts of reform, and that predicting the impact of NAFTA looked at the impact on the output or exports of specific industries, but was silent on how their location might be affected.[3] However, the New Economic Geography (Krugman 1991), building on the interplay of agglomeration externalities of industry due to the availability of specialized labor or intermediate inputs and technology spillovers on the one hand, and transportation costs on the other, offered some tools to examine the question. In one possible scenario suggested by Hanson (1997), Mexico's traditional inward looking policies led industry to locate near concentrations of industry and population in central Mexico City and serve the peripheral regions- the south and the north, from this base. However, the progressive liberalization of trade with the US, arguably made locating nearer the US market more profitable shifting the center of gravity of the Mexican economy to the North, potentially in a dramatic fashion. The benefits of proximity to the border would likely dissipate with distance and, as some have argued, lead to an increased dispersion of welfare between north and south (See Nicita 2005).

However, such a dramatic shift accompanied by increased polarization with trade liberalization is not a foregone conclusion. To begin, theory remains ambiguous. As an example, Behrens et al. (2003) suggest that the finding of increased polarization with trade liberalization depends critically on the specific modeling of transport costs.[4] Second, both Krugman and others (see also Head and Mayer 2003 for a review) have noted the remarkable persistence of patterns of industry distribution over very long periods of time and large changes in economic environment. This may arise from the power of accumulated agglomeration externalities sparked initially by often trivial historical accident in Krugman's view, or perhaps, the importance after all of natural advantages that anchor industries to their existing locales. Davis et. al.(1997) argue that Heckscher Ohlin Vanek performs surprisingly well as a theory of the location of production in Japanese regions to the degree that they argue that Krugman-style geography models add little. Ellison and Glaeser (1999) find that only 21% of US industries exhibit levels of geographical concentration significantly higher than those predicted by natural advantages such as weather or natural resources. Redding and Vera Martin (2005) show that both theoretically and in 45 regions of Europe, factor

[3]See for example, Maloney and Azevedo (1995) and Lustig, Bosworth and Lawrence (1992) Lawrence specifically acknowledges the lack of reference to spatial considerations. p. 65.
[4] In fact, Hanson's paper argued that the emergence of a second pole would lead to compression of the wage distribution rather than divergence.

endowments are important in determining the location of production.[5] In either the NEG or HOV based views, it is not clear whether the sudden increase in demand from abroad, and an increase in supply of cheaper and better quality inputs, may lead to the displacement of existing non-border growth poles, or their re-energizing. Both scenarios are consistent with very localized and isolated hot spots, or large multi-state agglomerations distributed with no particular relation to the border.

In Mexico, these types of considerations suggest that the emerging geographical patterns of economic performance may be more subtle and hard to predict. It is possible to imagine that the increased costs of exporting from established central industrial locales such as Queretaro, Aguascalientes, or Guadalajara might be offset by their well trained workforces and lower levels of congestion.[6] Domestic and potential foreign firms in these areas serving the Mexican market may be further energized by the increased access to cheaper and higher quality inputs from abroad and the lowered risk implied by, especially, the NAFTA agreement.[7] Further, the location of some potential growth industries is clearly driven by immobile endowments not necessarily concentrated on the border. Esquivel (2000) finds that two-thirds of differences in Mexican state income is driven by natural characteristics (climate, vegetation).[8] NAFTA potentially has a stimulative impact on non-border areas with natural endowments when it eliminated import restrictions to the US on mangos (produced in Guerrero, Michoacan), pineapples (Veracruz, Oaxaca, Tabasco), and grapes in 1994 and asit phases out restrictions on tomatoes (Jalisco) and avocados (Michoacan) by 2008.[9] Both agricultural production and exports made large gains in the post-NAFTA period.[10] REWRITE

Further, other forms of non-road transport may offer low cost transport to the US market for non-border regions. The two largest airports after Mexico City, are found in

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5 Theoretically they show this should be the case regardless of the degree of factor mobility. Working in a similar tradition, Bernstein and Weinstein (2002) reintroduce the importance of transport costs as a means of anchoring the indeterminacy intrinsic to HOV when the number of goods exceeds the number of factors.

6 See Hanson (2001) for a discussion of the offsetting impacts of economies of agglomeration and diseconomies of congestion.

7 See Lustig (1992) for a discussion of the latter point that NAFTA was significantly about signaling to foreign investors that the country was locking in the rules of the game.

8 See Gallup, Gaviria and Lora (2003) for and english summary of Esquivel’s findings.

9 No attempt is made to be comprehensive here, merely to show that these central and southern states cultivate these crops, some almost exclusively, and hence were likely to benefit from NAFTA.

10 See Lederman, Maloney and Serven for a discussion of the resilience of Mexican agriculture.

Jalisco (center-south) and Yucatan (South). Airlift capacity, along with its high level of human capital, good governance, was critical to Intel's plant location in south-of-Mexico Costa Rica and is important to the long established computer industry in Guadalajara, Jalisco.[11] Yucatan also benefits from the shallow water port of Progreso that offers easy access to US ports in the Gulf of Mexico as well as those in Central and South America and the Caribbean. It is perhaps not surprising that in 2003, Yucatan had the second highest concentration of maquila employment of a non-border state exceeded only by Jalisco. The port of Veracruz, the entry point for Mexico's first globalizing influence in the 16th century, remains Mexico's most important with extensive road and rail networks that connects the central and southern states, again to the Gulf of Mexico ports. Given this ready water access, *all other endowment equal*, a southern pole or a southeastern corridor enjoying the same benefits of proximity would seem as plausible than the region being left behind.

In fact, to date, there is very little evidence that either the 1985 unilateral trade liberalization, or NAFTA has led to a correlation of growth with distance from the border. At the wage level, Hanson (1997) himself did not find that the North-South wage gradient steepened after 1985. Using state per capita income data, Rodriguez-Pose and Sanchez-Reaza (2005) find no relationship at any time period and our background regressions confirm this.[12] Esquivel (2000) finds no relationship of distance with either level of income or growth. Chiquiar (forthcoming) finds a relationship of changes in growth with distance, but this appears to be a result very particular to the 1970-1985/1985-1999 difference that does not survive breaking the period into a post GATT (1985-1993) and post NAFTA periods 1993-2002.[13] In sum, the geographical patterns of growth with liberalization are likely to be richer than at first thought.

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[11] Rodriguez-Clare(2001) notes Costa Rica's better infrastructure in this area gave it the edge over Chile.

[12] Running a simple convergence regression for 1970-2002, 1970-1985, and 1985-2002, we find that distance never enters remotely significantly. Putting in regional dummies suggests that the Chiapas-Oaxaca-Guerrero region did unusually poorly relative to other regions both in 1970-1985 and 1985-2002. Results available on request.

[13] Nicita (2004) ex post simulations find that gains in household welfare from trade liberalization were distributed broadly along a gradient from the North. However, the core estimations driving the simulations, the pass through of tariffs to prices, imposes a linear distance from the border interactive term that, in turn, implies that the predicted values used in the simulations will show the same gradient pattern. To be convincing, we would want to use the actual decline in prices in each state during liberalization.

Exploring Space

Sigma, and Beta convergence approaches offer point estimates of the central tendency of the data toward convergence or divergence. However, as Quah (1993) notes, they obscure vast amounts of information on the dynamics of relative income movements among states and do not shed light on the spatial dimensions of growth. As an example, simple plots of the distribution of income levels and growth rates (available on request) confirm Juan Ramon and Rivera-Batiz (1996) findings of a concentration of both in the period 1970-80 consistent with parametric convergence tests findings. However, from 1985 onwards a prominent right tail appears in both levels and growth rates suggesting that a group of states have detached from the others. Such snap shots of the distribution can be informative, but they hide important information, and in particular, how we get from one snapshot to another. We can ask, for example, whether the outliers in the extreme right tails in plots of the growth distribution are the same states who persistently show higher growth, or whether over the longer term, the distribution is broadly symmetric with random states sometimes experiencing extraordinary growth. The former would be consistent with the emergence of a spatial growth pole, the latter is not.

A substantial literature has followed Quah's lead in constructing Markov transition matrices which tabulate the probabilities of states moving among a finite number of intervals of the national income distribution and hence characterize the dynamic patterns of relative income movements.[14] To avoid problems associated with the naïve discretization of the income distribution (Bulli 2001), Quah (1997) proposes approximating a continuous distribution with the use of kernel density estimates.[15] We begin by constructing these for Mexico before and after the periods of trade liberalization. One advantage of both the transition matrices and the kernels is that they can be conditioned on state characteristics, including geographical location, to permit inference to permit inference about the spatial dimensions of Mexico's growth process. We are interested in knowing if there is evidence of "spatial correlation" or "spatial dependence" where either income levels or growth rates are

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14 See, for example, Fingleton, 1999; Rey, 2001; Lopez-Bazo et al, 1999; Puga, 1999 Employing these techniques for Mexico, Garcia-Verdu (2002) again finds no evidence of convergence in the post 1985 period.

[15] For the methodology behind estimating these kernels, readers are referred to the original paper (Quah 1997).

correlated by geographical location and whether groups of states have emerged as either positive or negative growth poles.

The kernel analysis suggests visually possible patterns but is not well suited for statistical inference. We offer two sets of parametric tools to complement the visual analysis. First, to test whether two kernels differ between time periods, we offer a first approximation by testing for structural break in their discrete time analogues, transition matrices capturing the movement of states among five income quintiles. Each *i*,*j* entry of the matrix represents the probability of transiting from income state *i* to income state *j* in a five year period time.[16] Following Bickenback and Boden (2001), we construct a Q statistic that tests for structural break between the subperiods, both at the individual interval level and for the matrices as a whole.

$$Q_i = \sum_{j \in B_i} n_i \frac{(\hat{p}_{i\,j(1970-85)} - \hat{p}_{ij(1985-2002)})^2}{\hat{p}_{ij(1985-2002)}} \sim \chi^2(B_i - 1)$$
$$B_i = \{ j : \hat{p}_{ij(1985-2002)} > 0 \}$$

Where $\hat{p}_{i\,j}$ is the probability for a state to transit from income interval *i* to income interval *j*

For the whole matrix, the test is simply $Q = \sum_i Q_i$

Second, we introduce parametric measures of spatial dependence common in the spatial statistics literature but only recently applied to the study of economic growth. [17] The first is Moran's I statistic (the Global Moran; see Anselin 1988 and 1995) that is calculated for each period *t* as

$$I_t = \frac{n}{S} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} z_i z_j}{\sum_{i=1}^{n} z_i^2}, \quad \forall \quad all \quad t = 1,2,...,T$$

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[16] The asymptotically unbiased and normally distributed Maximum likelihood estimator of p_{ij} is determined by $\hat{p}_{ij} = n_{ij} / \sum_j n_{ij}$, where n_{ij} is the number of transitions from income class *i* to income class *j* over a period of time.

[17] See Rey (2001)

where n is the number of states; w_{ij} are the elements of a binary contiguity matrix W[18](nxn), taking the value 1 if states i and j share a common border and 0 if they do not; S is the sum of all the elements of W; and z_i and z_j are normalized[19] vectors of the log of per capita GDP of states i and j respectively. Positive (clustering of similar values) spatial dependence, whereas negative spatial correlation (clustering of different values). Statistical significance can be tested comparing the Moran's I statistic with its theoretical mean and using a normal approximation.

The global Moran may, however, could conceal patterns of co-movement in particular growth poles or convergence clubs. These can be more easily detected by the "Local" Moran which calculates the Moran between an individual state and its *spatial lag.* Broadly speaking, in the same way that in time series econometrics a Durbin Watson test would capture co-movement of contemporaneous residuals with those of neighboring (lagged) time periods, the local Moran captures co-movement with neighboring states (its spatial lag).

$$I_i = \frac{z_i \sum_j w_{ij} z_j}{\sum z_i^2 / n}$$

The local Moran can be interpreted as an indicator of spatial clustering, either of positive correlation or negative where the null hypothesis is no spatial dependence. Local clusters are identified when the statistic is significantly different from zero.[20] In principal, the moran will also identifying the existence of comovements in states driven the presence or intensification of a gradient, for instance, from the US border. Further, in practice both the global and local Morans, the "neighborhood" may be defined in many ways: contiguity as defined above, but also, for instance, states lying a similar distance from the border.

[18] Distance based matrices have been also employed giving similar results to the above presented (results available upon request).
[19] The $z_i = ln(GDP_{it} / GDP_t)$ denotes the logarithm of the Gross Domestic Product per capita of region i in period t, (GDP_{it}), normalized by the sample mean of the same variable, GDP_t (De la Fuente, 1997).

[20] Since the distribution of the statistic is usually unknown, Anselin (1995) suggests a Montecarlo-style method to generate it, consisting of the conditional randomization of the vector z_j. That is, Moran statistics are calculated between state i and a large number of hypothetical "neighborhoods" constructed as random permutations of states drawn from the entire sample. Then, the true neighborhood Moran is compared against this distribution.

II. Data

The Mexican National Institute of Statistics, Geography and Information (INEGI) tabulates official income data for Mexican 32 states GDP for 1970,1975,1980,1985,1988, and then annually for the period 1993-2002. We follow Esquivel (1999), in making several corrections to this data. First, most oil is pumped from the states of Tabasco and Campeche, but the attribution of oil revenues has changed without obvious cause over time. Though the revenues are in fact allocated to all states via a federal sharing formula, in some years they were entirely attributed to Tabasco, and in others to Campeche. We tried to correct for this, excluding the oil production as captured in the mineral production category of the state accounts, but still found the resulting growth series to be too erratic and exaggerated to be credible. We attribute this behavior to unresolved petroleum accounting issues since the remaining 30 non oil producing states behave more reasonably.[21] Though dropping these states clearly implies losing some of the spatial story, we find it preferable than contaminating the analysis with clearly unreliable series.

Second, we also corrected populations figures for Chiapas and Oaxaca for years 1975, 1980, 1985, 1988 as the 1980 census, when compared to other household census appears to have understated the state's population induced distortions in the GDP per capita.[22].

Finally we have merged the state of Mexico with Mexico DF (Federal District), the capital. The rationale for this aggregation stems from the fact that the two states have long been part of a common industrial belt and there exist strong labor market linkages between them which may lead to an overstatement of the capital city's per capita income. This has led to reported population in the Mexico DF has remaining stable over the last 20 years while the population in the state of Mexico doubled. We run the analysis both with and without this aggregation (results available on request) and, while the fundamental story does not change, the more moderate growth behavior of the aggregated capital city we find more plausible and we report those results.

[21] In fact, the state of Chiapas also produces some very modest amounts of oil and we subtracted this off from the state product series in 1975 and 1980.

[22] Population figures for years 1975, 1980, 1985, 1988 for Chiapas and Oaxaca were extrapolated using yearly population growth rates between 1970 and 1990. According to official figures, the mining production over GDP for Chiapas went from 7.5% in 1970 to 18% in 1975 up to 45% in 1980 and back to 7% in 1985. Clearly, years 1975 and 1980 saw arbitrary assignments of oil production to Chiapas. We have corrected for this as to allow the ratio mining production over GDP to be 7.5% for the outlier years .

In sum, we have 29 states measured at 5 year intervals with 3 observations before the unilateral trade liberalization of 1985 and 3 after.[23] Table 1 and figures 1, 2a and 2b present that data and suggest that in the year 2000 regional differences in Mexico were vast: the GDP per capita of the poorest state, Oaxaca in the South was only 23% of the richest, Nuevo Leon in the North.

III. Identifying Regions- covariance of income levels.

We first ask whether there has been a major reordering of income levels across time and whether there has been correlation across groups of neighboring states that would constitute a region or that would suggest emerging gradients. Figures 3a and 3b plot the stochastic kernel as well as its contour plots for levels of per capita income for the 1970-85 and 1985-2002 periods respectively. Both plots present state income relative to the country ("country-relative") in time *t* on the Y axis and in time *t*+5 on the X axis. The exact scale is used in both the pre and post-liberalization periods to facilitate inference about changes in the variance of the kernels. The cross-hairs depict the country average in period *t* and in *t*+5. A couple points merit highlighting.

First, if there were no movement at all among states, figures 3a and 3b would consist of a bisecting plane along the 45 degrees line shown. The fact that states do shift relative position gives the kernel its volume. Slicing the volume parallel to the X axis reveals the distribution of states at each initial income five years later. Again, the advantage over the simple distribution plots is precisely that we can see changes of position that might be hidden by identical "snap shot" distributions. Slicing parallel to the XY plane generates contour plots that show the relative probabilities of finding combinations of initial and final incomes.

Second, significant income convergence would result in a rotation of the kernel toward the Y axis. States with lower incomes in *t* would have higher *relative* incomes in *t*+5 and vice versa. Divergence would lead to the reverse.

For broad illustrative purposes, we introduce a state label at the position corresponding to the average value for each state. This reference is only approximate since

[23] When estimating the stochastic kernels and the transition matrices the years 1970, 1975, 1980, 1985, 1988, 1993, 1998 and 2002 were used. We tried to keep the 5 year period interval and at the same time avoid the 1995 crisis which would have distorted our results.

the kernel is estimated three time points for the each state, but given the revealed persistence in relative income levels, they are informative.

In fact, the most salient feature of both figures is the high persistence in the distribution. The probability mass is mainly concentrated in the diagonal of the plot showing that states did not significantly change their relative position. States located above the 45 degree line saw a worsening of their relative positions over time and those below, an improvement.

Though the persistence is clear, striking differences emerge between the pre- and post-85 kernels. The single peaked kernel in figure 3a has become a double or even triple peaked kernel suggesting the formation of convergence clubs over the post-85 period. Several forces are at play driving this evolution. First, the bottom end of the distribution has become more compressed around 0.70 of the NAI (National Average Income) suggesting convergence toward the mean of the very poorest states. Second, above average states converged towards 1.3 of the NAI depopulating the center of the distribution. Finally, the states of Mexico, Nuevo Leon and Quintana Roo grew in income enough to have formed the last peak of the distribution with incomes above 1.7 NAI. Another evolution, important to the finding of reduced beta convergence, is the fact that the poor states are clearly below the 45 degree in the pre-liberalization period (2a) and on or above it in the post liberalization period (2b). This suggests reduced upward mobility of the poorest states in the post liberalization period.

The discrete transition matrices confirm the continuous kernel story. The persistence of income rankings is suggested by the high probabilities of remaining in the same interval tabulated along the main diagonal of the matrix (table 2). The *Q* statistics do suggest that the pre- and post-1985 matrices are statistically different from each other at the 1% level and a large part of the reason appears to be changes in the dynamics of the poorer states suggested above. For instance, the probability of a state in interval 1 being found in that same interval in five years was 80% prior to 1985 and 93% after 1985. States in quintile one and two were able to move upwards in the distribution with probability 7% and 5% respectively in the post 1985 period against 20% and 29% in the previous time span suggesting that the increased sigma dispersion was partially caused by a stagnation of the poorer states.

The spatial dimension

The question is then whether these convergence clubs translate into geographical "regions" as well. Quah identified a similar "twin peaks" phenomenon in the kernel derived from a international cross section of per capita incomes and found it to be geographically driven- regional clusters of poor countries were getting poorer, the agglomerations of rich countries were getting richer. To use the kernel density plots to see if the same geographical patterns are emerging in Mexico, we regenerate the kernels replacing t+5 with the income of the state relative to the average income of its contiguous neighbors ("neighbor-relative") in t. If the local and economy wide distributions of income are similar, that is, there are no clusters of states with similar incomes, we would find a concentration of probabilities along the main diagonal. If, on the other hand, poor states are found with poor states and rich with rich, we should expect a rotation toward a vertical line at unity- a country-relative poor state will have the same income as its neighborhood.

Figure 4a plots the spatially conditioned kernel density plots. Several points merit note. First, geography does not determine destiny in Mexico to the degree that it appears to globally. Had the income clusters identified previously been totally determined by space, the three observed peaks would have been aligned along the vertical line at unity on the Y axis. However, the post 85 figure is fairly similar to the multiple peaked unconditional kernel of figure 3b and there is a large group of states (for example Zacatecas, Tlaxacala, Michoacan, Nuevo Leon) whose mass lies largely on the 45 degree line. In the post -85 period the intermediate peak mainly consists of the northern states of Baja California Norte, Baja California Sur, Coahila and some successful central states such as Queretaro, Jalisco and, Aguascalientes (recently arrived) who show negative spatial correlation with neighbors. Quintana Roo and Mexico similarly constitute unusually high income areas, the former joining Mexico and Nuevo Leon as especially rich states in the third cluster identified on figure 3b. Even post liberalization, the richest states could not be more independent spatially being, as they are, from three different regions of the country. We do not find Quah's dramatic convergence clubs of rich and poor states.

However, there is evidence of spatial dependence that would suggest regional effects. Prior to 1985 there is some rotation and compression of the upper mass that suggests that, particularly among northern states of Baja California Norte, Baja California Sur, Chihuahua and Tamaulipas there is a nascent convergence club in incomes. However, as the border convergence club strengthened, the second line of states did not follow and hence we do not see a strong rotation of the "north" broadly imagined toward the Y axis. Sinaloa, Zacatecas, Durango and San Luis Potosi, all contiguous to the border states are relatively poor and lie largely on the 45 degree line. There is also a group of poor southern states-- Oaxaca, Guerrero, Puebla and Chiapas and Vercruz-- found to be better off relative to their neighbors than they are relative to the country. For example, Chiapas' income is around 50% of the NAI but it is as rich as its neighbors (neighbor relative income is roughly unity). These suggest that there are potentially aggregations that we might call "border" and "southern" regions to test for statistically.

We are also interested in how the relationship to the US may affect states in a common way, even if not contiguous and we rerun the kernels with two additional definitions of neighborhood. The first is based on the traditional geographical bands ("bands") and is similar to the categories used by Hanson (2004): border, north non-border, center, south and Yucatan peninsula.[24] Second, we generate five categories based on distance by land to the US ("distance"). This is the specification that would most likely turn up evidence of a gradient as discussed by Hanson (1997). Table 3 presents the states associated to each one of the neighborhoods for the two classifications.

Figure 4b plots the US distance spatially conditioned contour plots[25] for the pre-and post-1985 using the bands-defined neighborhood. The strengthening of the border cluster becomes now particularly clear, since the new neighborhood of the border states does not include the relatively poorer second line states the way the contiguity matrix did. This is especially clear in the second period where Baja California, Chihuahua, Sonora, and Coahuila are all piled on the vertical axis. Nuevo Leon remains separate to itself. Baja California Sur, by virtue of being bumped into the category of second row states, is now a high performer in its neighborhood.

Second, there also seems to be a prominent clustering of the southern states of Oaxaca, Chiapas, Guerrero, Tlaxcala and Veracruz which becomes clearer in the second

[24] Our categorization differs from that of Hanson by the inclusion of Aguascalientes as part of the central states and Puebla,Veracruz and Tlaxcala in the South. We, however, run the calculations using the exact Hanson classification with almost identical results.

[25] For the sake of space we just present the countour plots.

period as Oaxaca, Chiapas, Veracruz and Guerrero all move closer to the vertical line at 1 in the X axis. This causes an extension of the kernel toward the vertical that suggests convergence in income. Nevertheless, we still observe the presence of clear outliers and the alignment along the 45 degree line of the majority of the central states indicating a high degree of spatial independence overall.

The kernel using distance to the US (not shown) is similar to that using the bands but the results are less clearly delineated. This arises mainly because the south is split in two leaving the poor states of Chiapas and Oaxaca associated with the far richer states of Baja California Sur, Quintana Roo and Yucatan.

In sum, the convergence clubs suggested in figures 3a and 3b partially map into border and southern regions of Mexico. However, there are no other obvious other patterns of spatial association or clustering in the rest of the country. For any of our definitions of space, northern and central states mostly align along the 45 degree line showing little resemblance with their neighborhoods.

Parametric measures of spatial dependence

To establish whether the patterns suggested by the spatially conditioned kernels are statistically significant we turn to the Moran statistics. Figure 5 plots Moran's I normal standardized values for the period 1970-2002 for the three different definitions of space considered, as well as the standard deviation of the GDP per capita for the same period as a measure of sigma convergence. What is immediately clear is that, viewing Mexico as a whole, spatial dependence in income levels has increased along with the sigma divergence after a period when both had fallen. The contiguity based neighborhood most closely track the standard deviation (with a correlation coefficient of 0.85), but the other neighborhoods arguably also follow a similar pattern, albeit, less clearly. The relatively subtle indications of spatial dependence suggested in the kernels emerge as statistically significant in the Moran test, most notably, consistent with the kernels above, in the bands measure that most clearly captures the border and southern concentrations of wealth and poverty.

The local Moran statistics identify whether particular groupings of states co-vary in a statistically significant way and largely confirm the observations from the kernels. We present them in several different formats. First, the maps in figures 6a and 6b show the geographical distribution of significant local Morans based on contiguity for both the 10%

and 5% levels for the years 1970 and 2002, the endpoints of our sample. Second, the Moran scatterplots accompanying the maps graph the level of income of the state against that of its spatial lag for the same period as a way of illuminating the relationships captured by the statistics. A significant positive slope suggests that rich states are found among rich (quadrant 1) and poor among poor (quadrant 3). Quadrants 2 and 4 represent cases where rich states are found among poor, or poor among rich respectively. In fact this is a less efficient and comprehensive way of presenting the information in the kernels but one which allows a clearer view of the relative position of the states. Finally, tables 4 offer more detail still by showing significance levels and signs of the Moran statistics at 5 year intervals across the sample for all three definitions of neighborhood. Three findings emerge.

First, in the early period, we confirm a cluster of poor states around Oaxaca, Guerrero, Puebla, Chiapas and Guerrero corresponding to the traditional "southern states." These appear strongly in the maps and in quadrant 3 of the scatter plots, and table 4 suggests that this relationship has been getting stronger across time for all definitions of neighborhood.

Second, using the bands or the distance measure, table 4 confirms that the border states considered as a block clearly stand as a pole of high income levels that has become stronger with time. However, the lack of any significance using the connectivity measure confirms that the income levels of the next row of states are not correlated with those of the border and hence it may not be so useful to talk about the "north" more generally. Baja California Norte and Baja California Sur, and Sonora appear in the quadrant 1 of the scatter plots as well-off states in better-off neighborhoods, and hence might be seen as a well-off convergence cluster located in the north of the country along the US border. However, these correlations seem to slowly disappear by the beginning of the 1990's and the North, as a spatial unity encompassing more than just the border states disappears. The higher income of the frontline states has not spilled over much to the next line.

In the center we find little in the way of convergence clusters. Most of the Central states are located in quadrants 2 and 4 almost suggesting a downward sloping line (if we abstract from the outliers) and a tendency for rich states to be found among poor and vice versa. The greater variance in income per capita of this region (see table 1) underlies the finding of a lack of spatial dependency: poor states such as Zacatecas, Michoacan, Hidalgo, Nayarit and rich states such as Mexico/DF, Aguascalientes and Queretao share the same neighborhood. Consequently, we do not find any significant Moran statistics in this area for any of the periods, with the exception on the negative values associated with Jalisco and Mexico/DF indicating that these two states are well-off states surrounded by poor neighbors. At this point these results suggest that the Mexico/DF agglomeration has not pulled along its neighbors.

Therefore, as regions with some degree of commonality of levels of income, the South exists, the North seems to be restricted to those states directly on the US border and there has not ever been a Center. The latter finding is perhaps unexpected if their performance were heavily influenced by the existence a north-south and Mexico City gradients. Their interaction might give rise to more complex income relations than, for instance, we see on the border, but it is not obvious why we should find an almost random distribution of rich and poor states.

IV. Any link between geographical evolution and divergence?

The next question is whether thinking of these grouping as regions helps us to explain the pattern of economic divergence that we see. Clearly, the post liberalization divergence is driven by many forces and disentangling them is complex. For instance, both Aguascalientes and Quintana Roo pulled away strongly from their local neighborhood while Mexico appeared to become less of an outlier in its neighborhood. All things equal, these would lead to greater divergence and convergence respectively. To get a more systematic, although still very imperfect idea of how much of the increased dispersion has a geographical component, we begin by following Shorrocks and Wan (2005) in applying techniques developed for subgroup decomposition of inequality. This simply involves partitioning the sample in a set of geographical regions and then calculating the two components of aggregate inequality; a weighted average of regional inequality (within-group component) and the between group component term which captures the inequality due to variations in average incomes across regions. We proceed we the decomposition of the mean logarithmic deviation:

$$E_0(y) = \frac{1}{n}\sum_{i\in N}\ln\frac{\mu}{y_i}$$

where N in our case is the number of states which are partitioned in M mutually exclusive and exhaustive groups (regions).

Figure 6 plots the evolution of overall inequality as well as the between group and within group components together with the ration of between group to total inequality (B/T). Several points merit attention. First, the mean logarithmic deviation basically retrieves the same pattern of evolution of inequality than the standard deviation in figure 5. Secondly, most of the increase in inequality (94%) between 1985-2002 occurs in the period 1985-1993, prior to NAFTA. Looking closely at this period, both the between group and the within group component grew, suggesting that although 60% of the increase in dispersion was inter regional, much of it occurred within regions. Third, the 1994-2002 period was relatively stable in terms of inequality. However differences across regions increase in a time where within group inequality was decreasing. Overall, the between group inequality can explain 72% of the increase in total inequality from 1985 until 2002 with much of this is explained by the regional level movements between border, south and "other" split: If we divide the sample in three regions (border, south and rest) between groups inequality explains 66%.

Growth

Additional information on what may be driving dispersion can be gleaned by looking at the evolution of the spatial distribution of growth rates. We can conduct an exactly analogous, although somewhat simplified, set of exercises to identify regional patterns of co-movement in growth (see annex for definitions). In the kernel plots in figure 7a alignment along the axis suggests persistence in growth rates: a fast growing state today will be fast tomorrow. [26] Two things emerge strikingly from the pre- and post- 1985 kernels. First, the mass of probabilities seems to occupy the four quadrants more or less equally: A state that grows fast today is as likely to grow slow tomorrow as to grow fast again. This is not so surprising when we remember that in the pre-liberalization period many of the northern states had alternating high and low growth rates due to the 1982 debt crisis which hit the most dynamic states hardest and something similar seems to have occurred at the end of the 1990s. The distribution shows greater variance in the post liberalization period, but still does not show strong persistence in growth rates. Conditioning on the contiguous neighborhood

[26] In this case we did not reference the states generating the mass of probabilities as the growth rates did not show any persistency over time so the period averages would be meaningless.

(figure 7b) suggests little in the way of growth convergence clusters. The central mass is fairly tightly aligned along the 45 degree reference in both the pre- and post- 85 periods. We rerun the kernels with the other two neighborhood measures and again find no obvious visual regularities.

The overall Moran I using connectivity and the regional bands suggests a degree of spatial dependence in the pre-liberalization period, but over time this dependence has decayed-there has been a de-spatialization of growth rates in Mexico. Using the distance from the US neighborhood measure, however, we see no spatial dependence until the 1994-2002 period, coinciding with NAFTA.

Since this is the only evidence of spatial dependence in the post-reform period, the Moran scatterplots are calculated using this measure of neighborhood. The local Morans (table 6, figures 10a and b) at first glance seem to suggest that spatial growth patterns are dominated by the north/south dichotomy. In the 1970-85, all measures suggest positive co movements among border states with their neighbors in the third quadrant of *low* growth states among *low* growth states, but no other clusters. This border cluster disappears in the post-liberalization period, but Chiapas, Guerrero, Oaxaca Tlaxcala and Veracruz replicate its behavior in the post-trade liberalization period: low growth states among a group of low growth states. Additionally, the connectivity based Moran suggests that Mexico/DF aggregation significantly under performs in the early period in a time when its neighborhood was doing much better. These findings are consistent with the income convergence observed before liberalization and the divergence after. What is striking, however, is that we do not observe a northern pole of growth in the post- liberalization period as a whole with any of our definitions of space. Instead, there is mild evidence of a central cluster of high growth in the states of Aguascalientes and Guanajuato.

Dividing the post-85 period into post-GATT and post-NAFTA sub-period yields consistent but stronger results (figures 9a and b). During the first sub-period, the only major development is the extremely poor performance of southern states, especially, Chiapas, Veracruz, and Tlaxacla. Although some southern states such as Puebla were growing above average, other poor Central and Northern states like Hidalgo Nayarit and Zacatecas performed below average while rich states such as Aguascalientes, Quintana Roo and Chihuahua grew steadily. These tendencies are consistent with increased income dispersion over this period but make clear geographical generalization difficult. Neither the north as a whole, nor the border constitute a pole of commoving states driving divergence.

The second sub-period is also characterized by increasing but less dramatic divergence. However, again the border states do not seem to constitute a growth pole. Nuevo Leon, Chihuaha and Coahuila perform above average and Coahuila and Nuevo Leon do show local Moran's that might suggest a mini-growth pole. But Baja California grows at below average rates and Sonora and Tamaulipas, at average rates. Clearly, this performance by rich states while poor states grow below average will contribute to divergence. But it is not the case that the border states as a group grew in a common way or dramatically outperformed the rest of the country.

A clear growth pole does emerge among in second line and central states of Aguascalientes, Guanajuato, Queretaro and Zacatecas. Since these states are roughly equidistant from the border, this, and not the comovement of the border states, is what drives the significant distance-based Moran I in this period. Since most are relatively rich states, their success suggests a potentially important dynamic outside of the North South dynamic discussed above. The South as a whole still underperforms, especially Guerrero, although the southern block seems less coordinated than when the entire post 1985 period is taken.

In sum, it seems difficult to argue that a special reaction to NAFTA of the states closest to the border was the driving force behind divergence. The consistently poor performance of the south which does form a regional cluster, does emerge as a central element in the story.

V. Conclusions.

This paper employs established techniques from the spatial statistics literature to investigate how the post 1985 trade reforms affected spatial patterns of economic activity. Looking at levels of per capita state income, we find that very clearly a south exists, but the north seems to be restricted to those states directly on the US border, and there has never been a center. The latter finding is perhaps unexpected if the performance of the center states were heavily influenced by the confluence of a north-south and a Mexico City gradient. Our guess is that previous parametric findings of a gradient were driven by the imposition of a linear relationship with distance from the border that identified off the high north and south incomes but obscured the randomness in between. Their interaction might give rise to more complex income relations than, for instance, we see on the border, but it is not obvious why we should find an almost random distribution of rich and poor states. That said, the Thiel decompositions suggest that reversal of the pre-1985 convergence seems to no small part driven by the divergent paths of these two regions.

However, the spatial distribution of growth suggest some additional complexity. Post liberalization period is not especially tied to closeness to the US border, and, consistent with our reading of the non-spatial parametric literature, do not offer strong support to an increasing gradient from North to South. The substantial divergence occurring in the 1985-93 period shows no traces of spatial dependence and seems unrelated to the consolidation of a faster growing northern block of even border states- only the south shows co-varying growth rates across this period. The sustained underperformance of the South, dating from before NAFTA, the treaty most affecting the local agricultural industries, and the superior performance of an emerging convergence club in the center of the country are also likely candidates for explaining much of the divergence occurring in the final period.

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Annex I: Conditioning of Kernels.

Definitions:

y_{it} the income per capita of state *i* in year *t*,
$\overline{y}_t$ the national average income per capita in year *t*,
y_{wt} th average income per capita of the spatial lag in year *t*.

Figures 9 a:

Kernels generated using three growth spans of 5 years each before and after 1985:

$$\left(\frac{y_{it+s}}{\overline{y}_{t+s}} \Big/ \frac{y_{it}}{\overline{y}_{t}} \right) - 1 \text{ conditioned to } \left(\frac{y_{it}}{\overline{y}_{t}} \Big/ \frac{y_{it-s}}{\overline{y}_{t-s}} \right) - 1$$

Figures 9b:

$$\left(\frac{y_{it}}{\overline{y}_{t}} \Big/ \frac{y_{it-s}}{\overline{y}_{t-s}} \right) - 1 \text{ conditioned to } \left(\frac{y_{it}}{y_{wt}} \Big/ \frac{y_{it-s}}{y_{wt-s}} \right) - 1$$

Table 1. Mexican 2002 GDP per capita by state, constant pesos 1993

	State	Region	Population (Thousands	GDP millions of pesos	GDP per capita	GDP per capita by region	Std/Mean
BC	Baja California	North	2,706	47,091	17,405	19,730	0.20
CO	Coahuila		2,444	49,651	20,314		
CU	Chihuahua		3,252	64,461	19,823		
NL	Nuevo León		4,046	105,270	26,019		
SO	Sonora		2,370	39,729	16,763		
TA	Tamaulipas		2,990	45,124	15,094		
BCs	Baja California Sur	Central-North	464	8,330	17,968	11,333	0.28
DU	Durango		1,536	18,953	12,341		
SL	San Luis Potosí		2,373	25,656	10,811		
SI	Sinaloa		2,697	30,628	11,356		
ZA	Zacatecas		1,410	12,534	8,887		
AG	Aguascalientes	Central	995	18,386	18,470	16,507	0.33
CL	Colima		569	8,119	14,263		
GU	Guanajuato		4,942	55,583	11,246		
HI	Hidalgo		2,330	20,364	8,741		
JA	Jalisco		6,639	95,731	14,420		
MX	Mexico and DF		22,796	482,133	21,150		
MI	Michoacán		4,181	33,871	8,101		
MO	Morelos		1,659	20,537	12,382		
NA	Nayarit		977	8,333	8,527		
QU	Querétaro		1,515	26,224	17,313		
CH	Chiapas	South	4,232	26,307	6,216	7,761	0.18
GE	Guerrero		3,221	23,979	7,445		
OA	Oaxaca		3,642	21,812	5,989		
PU	Puebla		5,362	51,219	9,552		
TL	Tlaxcala		1,022	8,011	7,841		
VC	Veracruz		7,225	60,395	8,359		
QI	Quintana Roo	Yucatan Peninsula	976	20,874	21,383	15,117	0.42
YU	Yucatán		1,737	20,142	11,596		
CA	Campeche	Not in the sample	737	16,789	22,785		
DF	Distrito Federal		8,813	327,009	37,107		
MX	México		13,984	155,124	11,093		
TB	Tabasco		1,996	17,050	8,542		
	Total		103,040	1,483,284	14,395		0.40

Figure 1: Mexican Regional Map

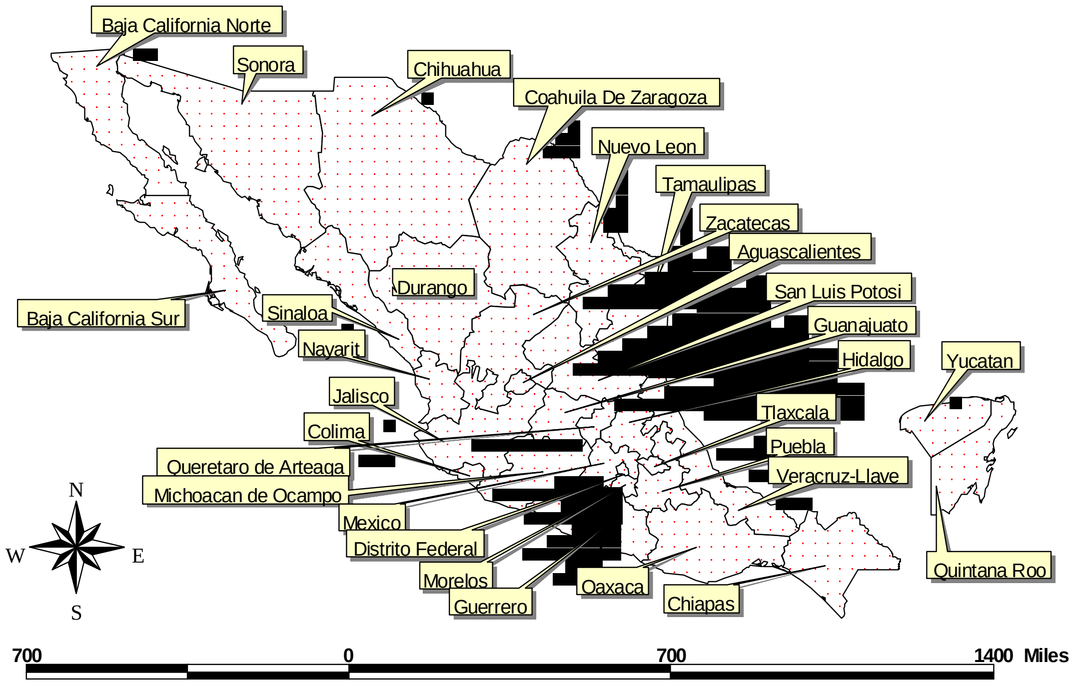


Figure 2a: Mexican states relative GDP per capita: 1970

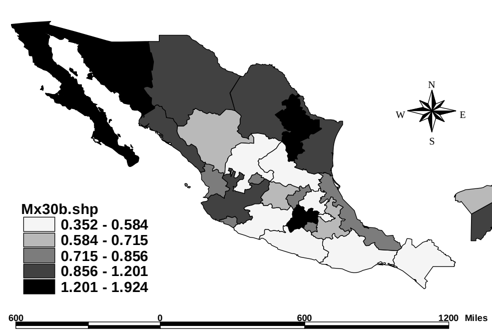


Figure 2b: Mexican states relative GDP per capita: 2002

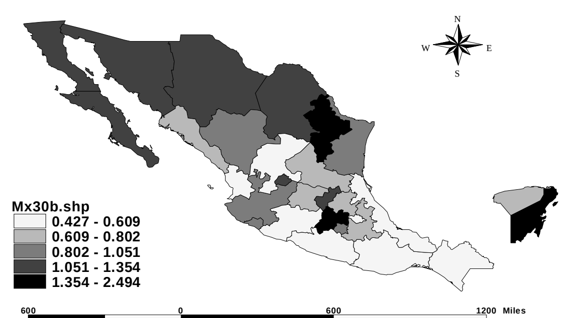


Figure 3a: Kernel Density Plots, Levels, Unconditioned:1970-1985

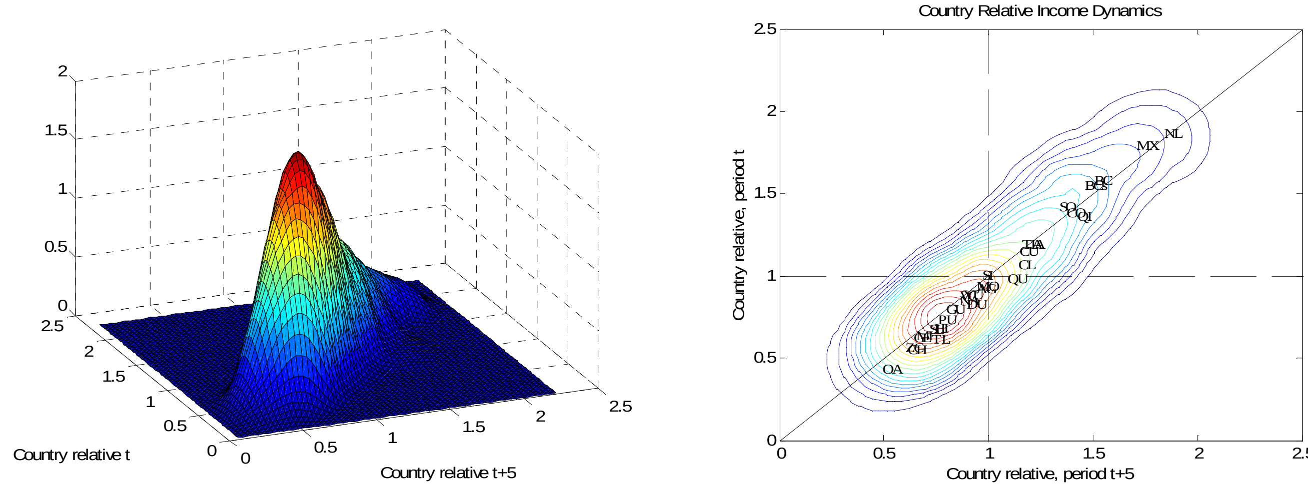


Figure 3b: Kernel Density Plots, Levels, Unconditioned:1985-2002)

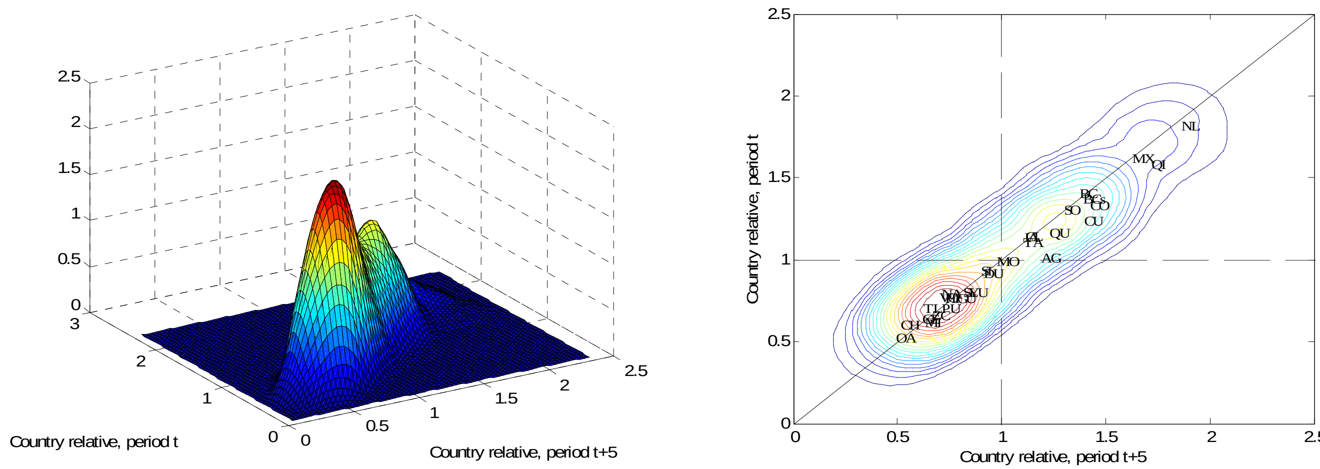


Figure 4a: Kernel Density Plots, Levels, Conditional on Spatial Lag (Neighbors): 1970-1985 vs 1985-2002

1970-1985 **1985-2002**

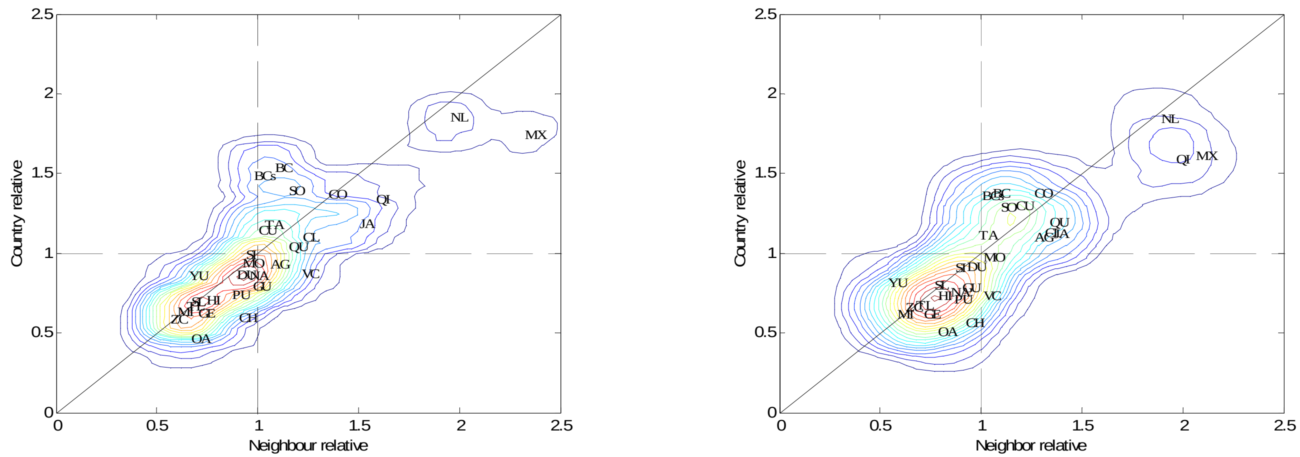


Figure 4b: Kernel Density Plots, Levels, Conditional on Spatial Lag (US Distance):1970-1985 vs 1985-2002

1970-1985 **1985-2002**

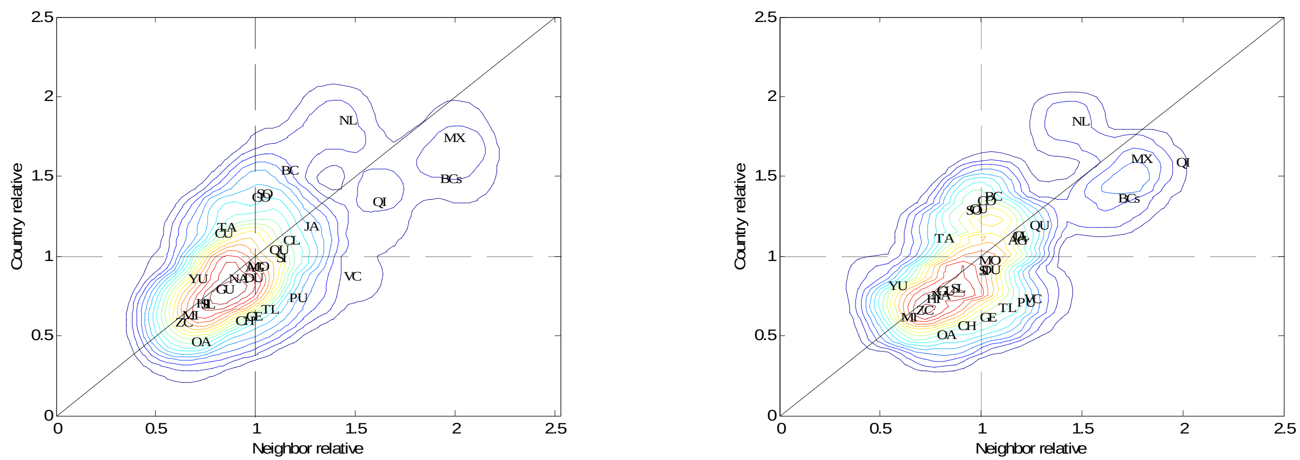


Table 2. Transition Matrices 1970-2002

Transition Matrix 1970-2002

Number		1	2	3	4	5
35	1	**0.86**	0.14	0.00	0.00	0.00
35	2	0.17	**0.69**	0.14	0.00	0.00
35	3	0.00	0.14	**0.77**	0.09	0.00
35	4	0.00	0.00	0.03	**0.80**	0.17
34	5	0.00	0.00	0.00	0.18	**0.82**

Transition Matrix 1970-1985

		1	2	3	4	5
20	1	**0.80**	0.20	0.00	0.00	0.00
14	2	0.07	**0.64**	0.29	0.00	0.00
21	3	0.00	0.14	**0.76**	0.10	0.00
13	4	0.00	0.00	0.00	**0.92**	0.08
19	5	0.00	0.00	0.00	0.21	**0.79**

Transtion Matrix 1985-2002

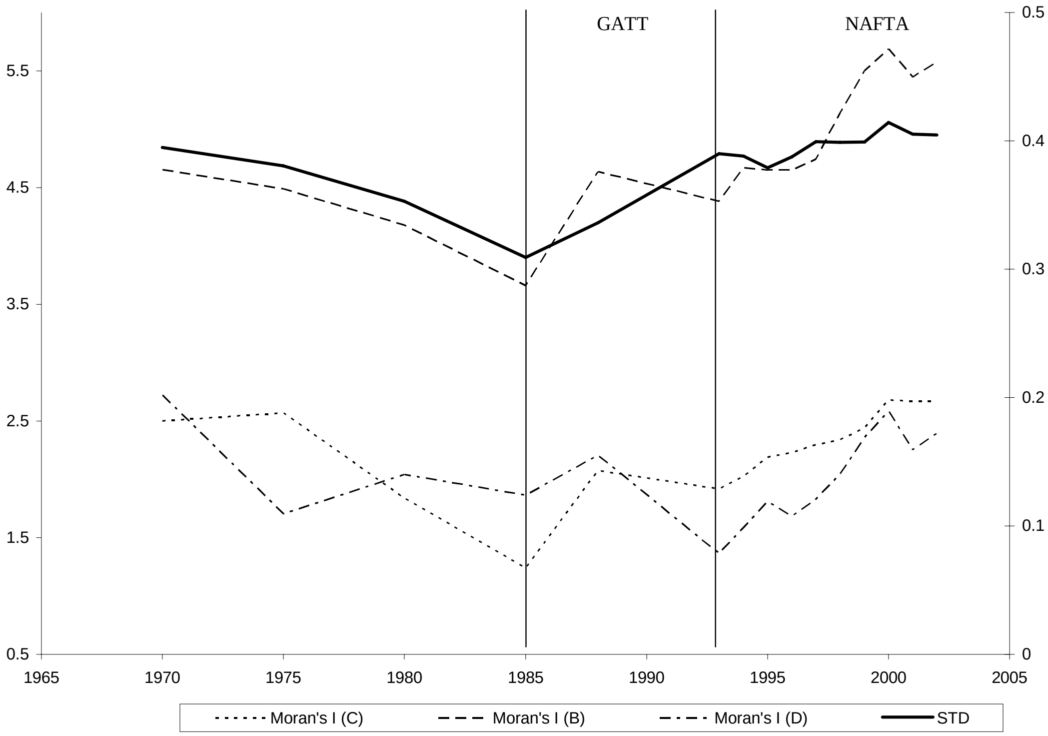
		1	2	3	4	5
15	1	**0.93**	0.07	0.00	0.00	0.00
21	2	0.28	**0.66**	0.05	0.00	0.00
14	3	0.00	0.14	**0.79**	0.07	0.00
22	4	0.00	0.00	0.09	**0.63**	0.27
15	5	0.00	0.00	0.00	0.07	**0.93**

	d.f	Q-statistic	P-value
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \mid i=1$	1	5.71	**0.02**
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \mid i=2$	2	18.92	**0.00**
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \mid i=3$	2	0.18	0.91
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \mid i=4$	2	4.68	0.09
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \mid i=5$	1	6.31	**0.01**
Ho: $\hat{p}_{i\ j(1985-02)} = \hat{p}_{i\ j(1970-85)} \forall i$	8	35.83	**0.00**

Table 3. State Classification According to Distance to the US Border

	Bands		**Distance to US border**
Border	BC CO CU NL SO TM	0 km-351 km	BC, CO, CU, NL, SO, TM
North	BC’s, DU, SI, SL, ZA	351 km-870 km	AG, GU, DU, QU, SL, ZA
Centre	NA, GU, CL, HI, JA, MX, MI, MO, AG, QU	870 km-1130	HI, JA, MX, MI, MO, SI
South	GE, OA, CH, PU, TL, VC	1130 km-1416 km	GE, CL, NA, PU, TL, VC
Yucatan	YU,QI	>1416 km	BC’s CH OA QI YU

Figure 5: Global Moran's I (levels) and Standard deviation 1970-2002



Note: C=contiguity matrix, B=Bands, D=Distance from the US

Figure 6a: Significance of Local Moran for GDP per capita 1970: Map and Moran Scatterplot

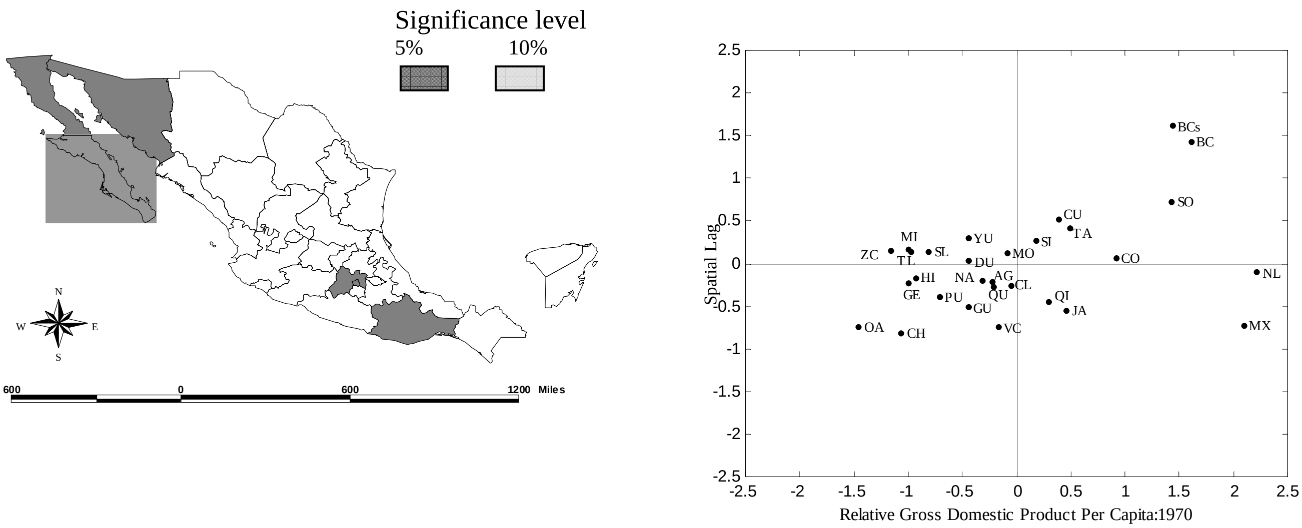


Figure 6b: Significance of Local Moran for GDP per capita 2002: Map and Moran Scatterplot

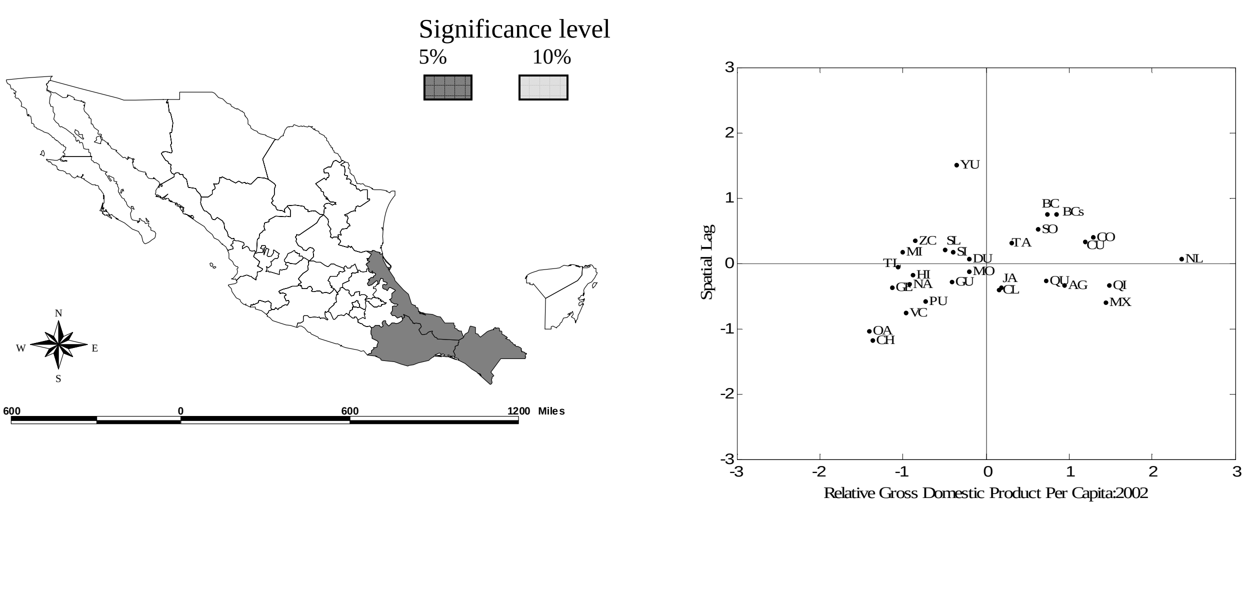


Table 4: Local Moran: Levels

	1970			1975			1980			1985			1993			2002		
	C	B	D	C	B	D	C	B	D	C	B	D	C	B	D	C	B	D
Baja California Norte	++	++	++	++	++	++	++	++	++	+	++	++		++	++		++	++
Coahuila De Zaragoza		++	++		++	++		++	++		++	++		++	++		++	++
Chihuahua		+	+		+	+						+		++	++		++	++
Nuevo Leon		++	++		++	++		++	++		++	++		++	++		++	++
Sonora	++	++	++		++	++		++	++		++	++		++	++		++	++
Tamaulipas		++	++		++	++		++	++		++	++		++	++		++	++
Baja California Sur	++		-				+											
Durango			+			++			+									
San Luis Potosi																		
Sinaloa																		
Zacatecas																		
Aguascalientes																		
Colima												--			--			-
Guanajuato																		
Hidalgo																		
Jalisco	-			-			--			--								
Mexico and DF	--			--			--			--			-					
Michoacan de Ocampo																		
Morelos																		
Nayarit																		++
Queretaro de Arteaga																		
Chiapas		++		+	++			++			+		++	++		++	++	
Guerrero		++			++			++		+	++			++			++	+
Oaxaca	++	++		++	++		++	++		++	++		++	++		++	++	
Puebla		++			++			++		+	++		+	++	+	+	++	+
Tlaxcala		++			++			++			+			++	+		++	+
Veracruz-Llave											+		++	++	+	++	++	++
Yucatan										-	-		-	-				
Quintana Roo																		

Note: C=contiguity matrix, B=Bands, D=Distance from the US

Figure 7: Between and Within Group Inequality 1970-2002

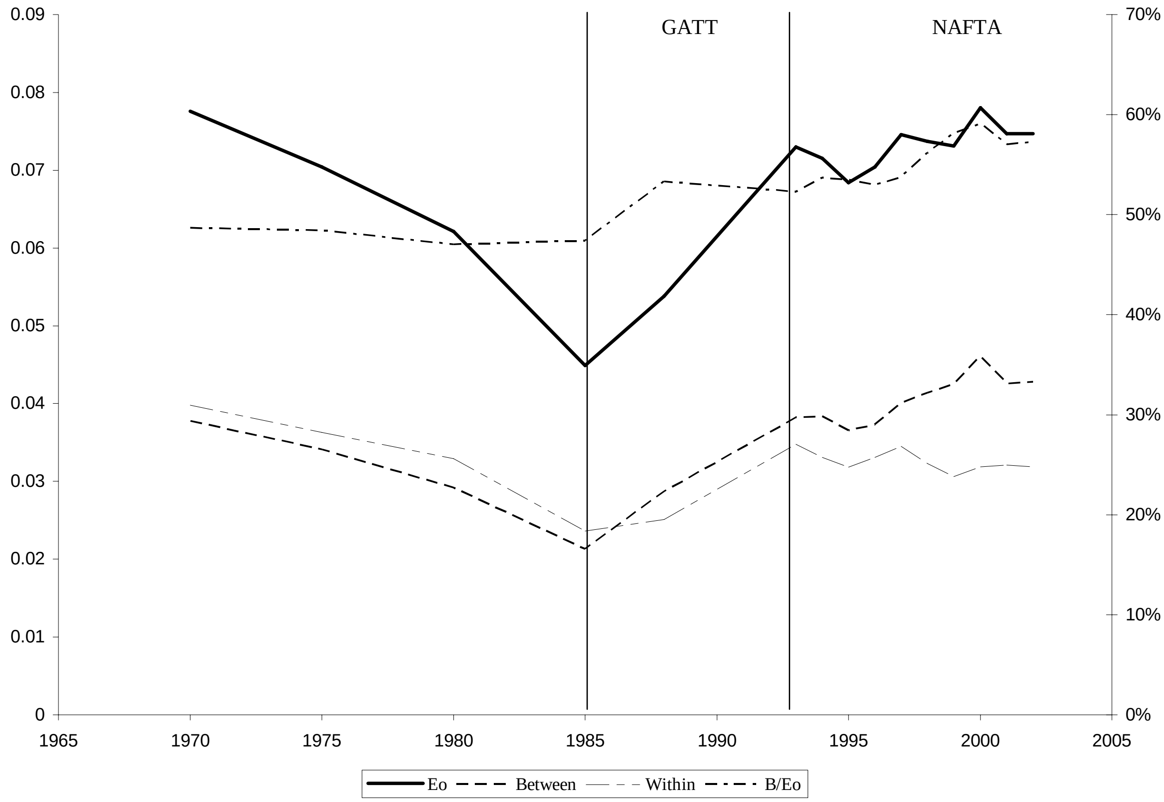


Table 5: Between and Within Group Inequality

Year	Eo(y)	Between	Within	B/Eo(y)
1970	0.078	0.038	0.040	49%
1985	0.045	0.021	0.024	47%
1993	0.073	0.038	0.035	52%
2002	0.075	0.043	0.032	57%

Contribution to the change in inequality.

All Regions	**Between**	**Within**
1970-1985	50%	50%
1985-2002	72%	28%
Border-South-Rest		
1970-1985	50%	50%
1985-2002	66%	34%

Figure 8: Global Moran's I (growth rates)

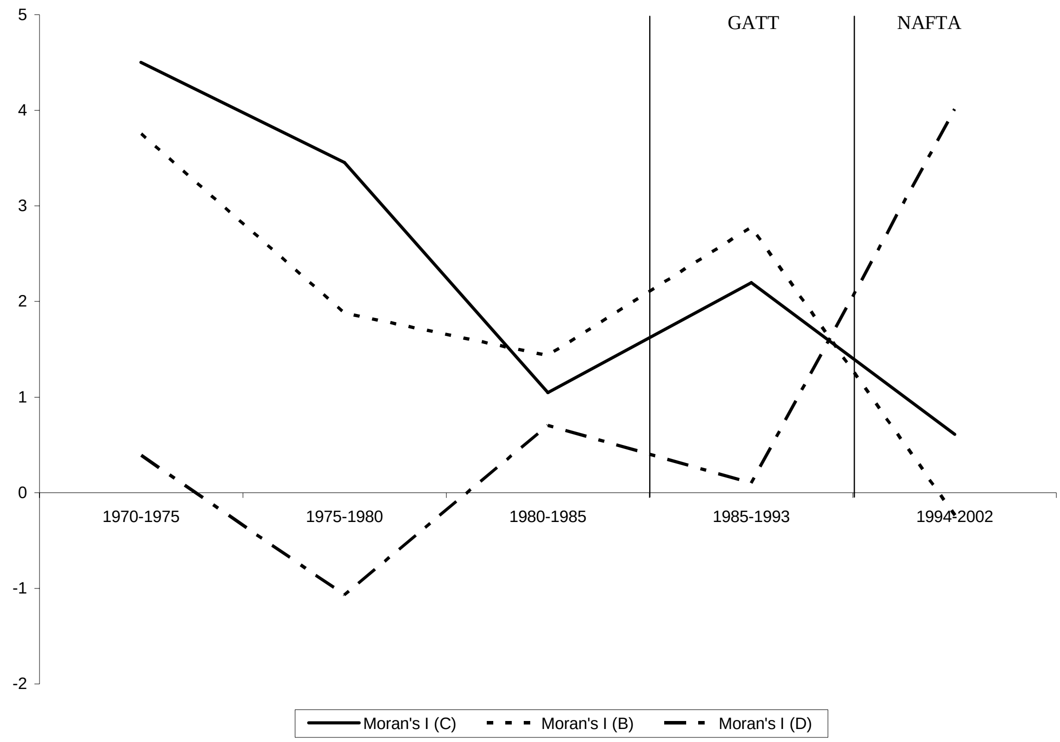


Figure 9a: Kernel Density Plots, Growth, Unconditioned: 1970-1985 vs 1985-2002

1970-1985 **1985-2002**

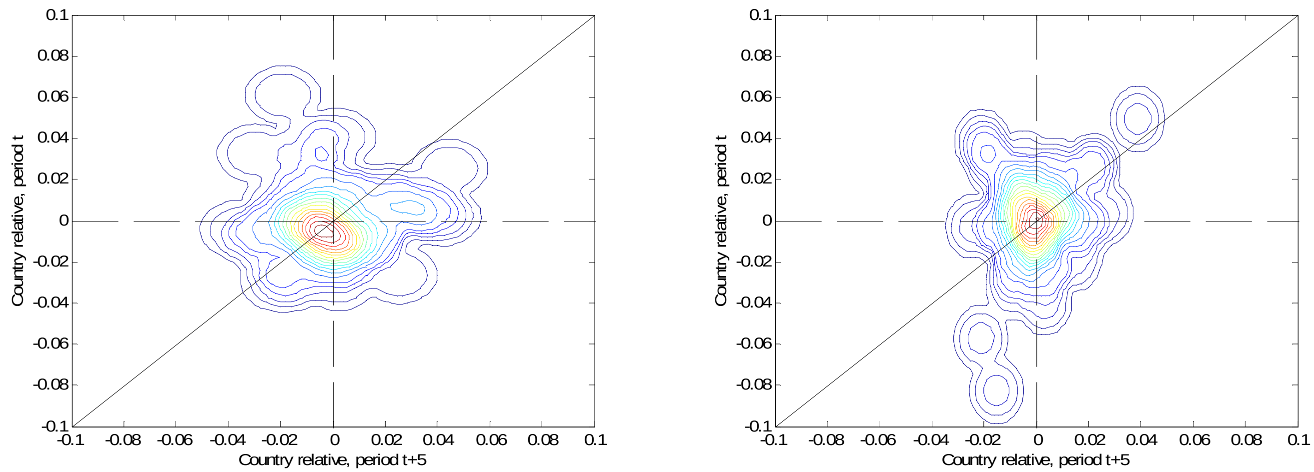


Figure 9b Kernel Density Plots, Growth, Conditional on Spatial Lag (Neighbors):1970-1985 vs 1985-2002

1970-1985 **1985-2002**

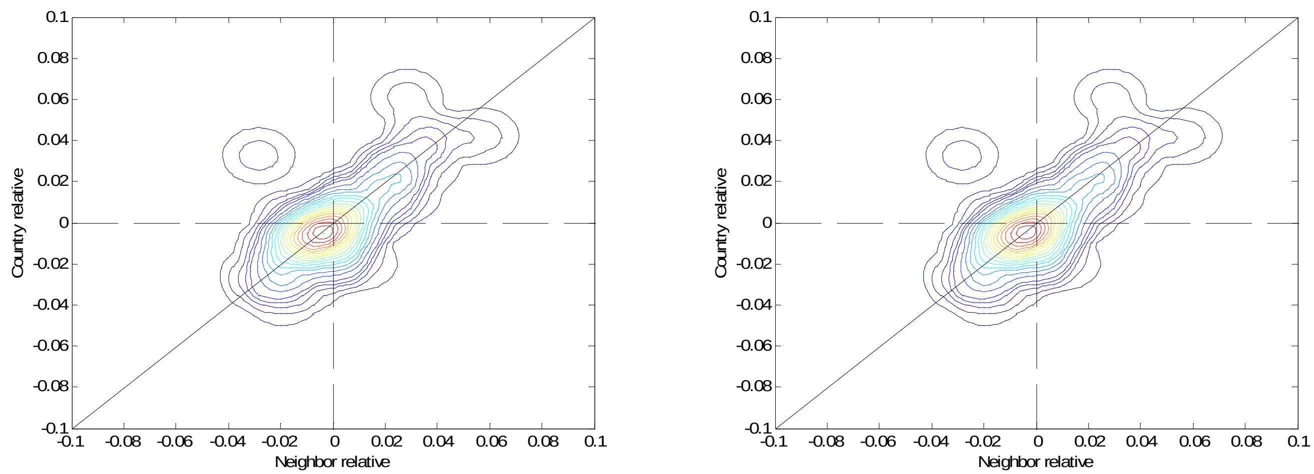


Table 6: Local Moran: Growth Rates

	1970-85			1985-2002			1985-1993			1994-2002		
	C	B	D	C	B	D	C	B	D	C	B	D
Baja California Norte	++		++									
Coahuila De Zaragoza			+	+							+	
Chihuahua												
Nuevo Leon		++	++							+	+	+
Sonora	++	++	++									
Tamaulipas		++	++									
Baja California Sur	+		-									
Durango												++
San Luis Potosi												+
Sinaloa												
Zacatecas										++		++
Aguascalientes						+						++
Colima												
Guanajuato						+				++		++
Hidalgo												
Jalisco												
Mexico and DF	--											
Michoacan de Ocampo												
Morelos											-	+
Nayarit					-	++			+			
Queretaro de Arteaga												++
Chiapas				++	++			++	--			
Guerrero					++	+				++	+	+
Oaxaca		++		+	++							
Puebla								+		-		
Tlaxcala		+			++	++		++	+			
Veracruz-Llave	-	--		++	++	++	++	++	++			
Yucatan							+					
Quintana Roo												

Note: C=contiguity matrix, B=Bands, D=Distance from the US

Figure 10a: Significance of Local Moran for Growth of GDP per capita 1970-1985: Map and Moran Scatterplot

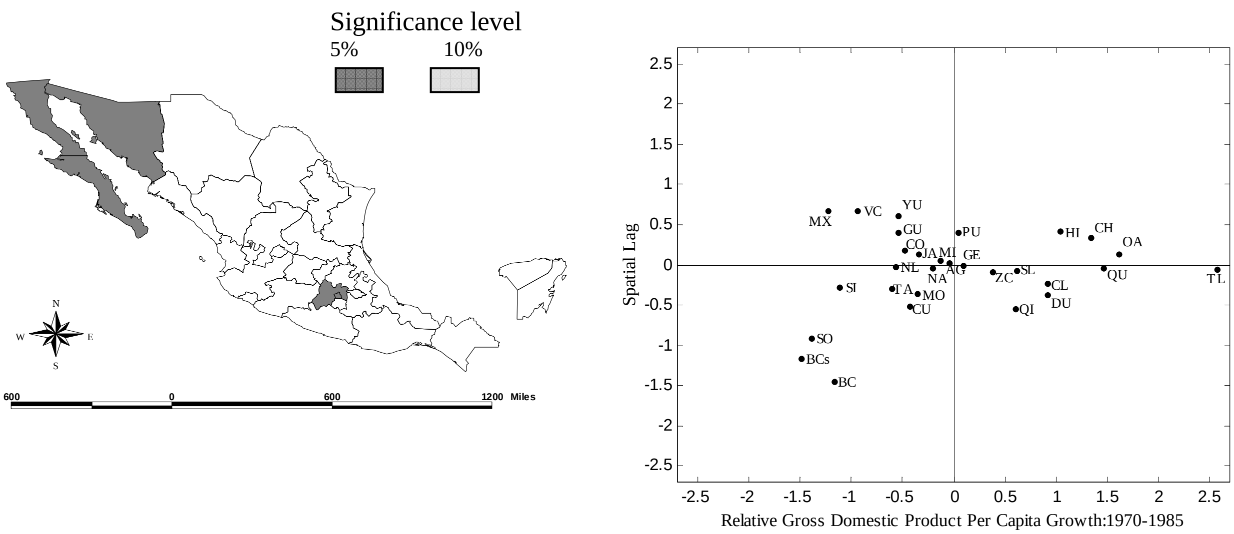


Figure 10b: Significance of Local Moran for Growth of GDP per capita 1985-2002: Map and Moran Scatterplot

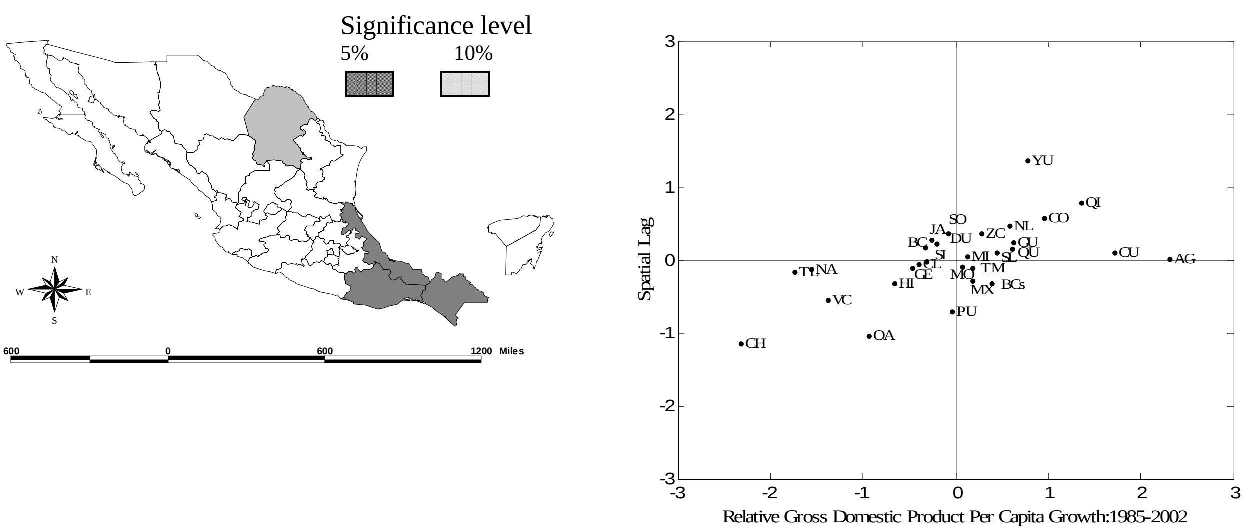
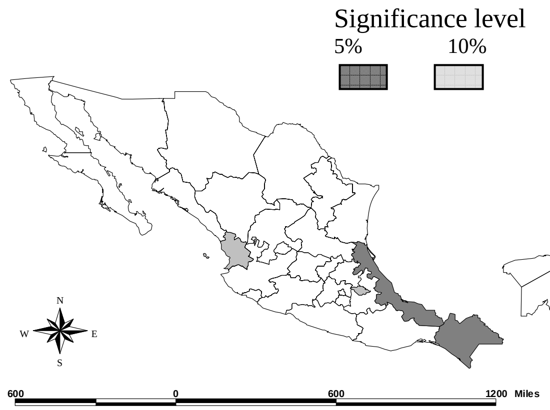


Figure 11a: Significance of Local Moran for Growth of GDP per capita 1985-1993: Map and Moran Scatterplot



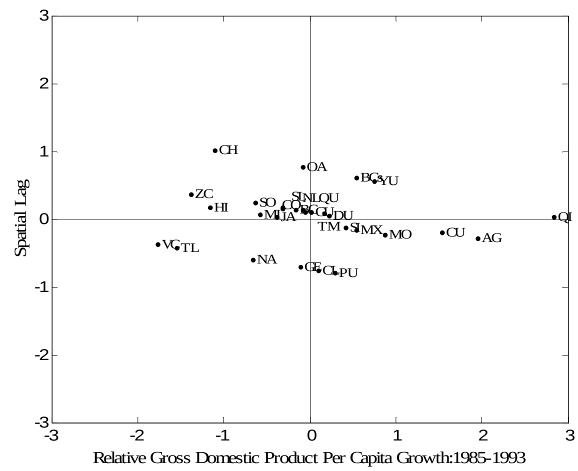


Figure 11b: Significance of Local Moran for Growth of GDP per capita 1994-2002: Map and Moran Scatterplot